HARSHAW TLD
NE·TECHNOLOGY
BICRON

BICRON • NE
6801 Cochran Road
Solon, Ohio 44139
Telephone: (216) 248-7400
(800) 472-5656
Telefax: (216) 349-6581

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120 AC
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Model LFM-2
Radioactive Material Detection System

User's Manual

Publication No. 1100-0-U-0996-001

* * * Release Date * * *

September 13, 1996

UNIT Electronics → Fuse $\frac{1}{4}$ Amp BUSS Type GMA-$\frac{1}{4}$

110 AC EXTERNAL ALARM FUSE →

ALARM settings Pg 18
ALSO QA manual (attached) Pg 7

Part No. 1100900
Rev A

FOREWORD

This manual contains installation, operation and maintenance instructions for the BICRON Model LFM-2 Radioactive Material Detection System. This manual is structured in such a way that a novice can use it to become acquainted with the instrument at a comfortable pace, yet the experienced user will find it to be a valuable reference tool.

Section 1.0 Introduction provides a general description of the system, its application, and specifications.

Section 2.0 Operating Instructions provides the instructions necessary for the daily operation of the monitoring system.

Section 3.0 Controls and Adjustments describes the system's controls and how to adjust them for normal operation.

Section 4.0 Installation Instructions provides complete instructions for the installation and initial setup of the monitoring system.

Section 5.0 Maintenance provides instructions for fuse replacement, battery charging and replacement, and calibration of the system.

Writing Conventions

In order to maintain consistency throughout this and all BICRON manuals, certain writing conventions have been followed for safety warnings. They are divided into three categories and defined as follows:

- DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. ***DANGER NOTICES ALWAYS APPEAR IN BOLD, ITALICIZED, UPPER CASE LETTERS.***

- WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury. **WARNING NOTICES ALWAYS APPEAR IN BOLD, UPPER CASE LETTERS.**

- CAUTION indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It may also be used to alert against unsafe practices. ***CAUTION notices always appear in bold, italicized letters.***

The definition of these safety warnings is according to ANSI Z535.4. The style of the warnings (bold, italicized, etc) is BICRON ♦ NE's.

In addition to the above, we have added the following warning:

- NOTE indicates a situation which has the potential for erroneous data collection, loss of electronic data, or damage to equipment, but which does not directly affect the safety of the operator with respect to this product. The responsibility for any safety consequences as a result of erroneous data lies solely with the operator. *NOTE notices always appear in italics.*

Table of Contents

Section Page

1.0 Introduction
1.1 Application 5
1.2 Description 5
1.3 Specifications 6

2.0 Operating Instructions
2.1 General 8
2.2 Monitoring 8
2.2.1 Precautions 9
2.2.2 Normal Conditions 9
2.2.3 Alarm Conditions 9
2.3 Visual Check 10
2.4 Source Check 10

3.0 Controls and Adjustments
3.1 Introduction 12
3.2 Description of Controls 12
3.2.1 Ratemeter Control Switch 12
3.2.2 Audio Switch 13
3.2.3 Volume Control 13
3.2.4 Response Control 14
3.2.5 Display Reset 14
3.2.6 Alarm Light 14
3.2.7 Remote Detector Connectors 14
3.2.8 Detector Status Lights 15
3.2.9 Power Switch 15
3.2.10 Recorder Output 15

4.0 Installation Instructions
4.1 Introduction 16
4.2 System Control Unit 16
4.2.1 Mounting 16
4.2.2 Positioning 16
4.2.3 Wiring 16
4.3 Remote Radiation Detector Assemblies 16
4.3.1 Mounting 16
4.3.2 Positioning 16
4.4 Cable Runs 17
4.4.1 Power Cable for the Control Unit 17
4.4.2 Interconnecting Cable 17
4.5 Initial Setup 17

Table of Contents (cont'd)

Section		Page
5.0 Maintenance		
5.1	Fuse Replacement	19
5.2	Battery Maintenance	
5.2.1	Recharging	19
5.2.2	Replacement	19
5.3	Calibration	20

Appendices

Appendix		Page
A	Quality Control Acceptance Procedure	A-1
B	Spare Parts List	A-2
C	Drawings	A-3

Illustrations

Figure		Page
1	LFM-2 System Control Unit	5
2	Front Panel	8
3	Rear Panel	10
4	"MODE" (Ratemeter Control) Switch	12
5	"AUDIO" Switch	13

1.0 Introduction

1.1 Application

The system is designed for use at hospitals, university laboratories and other institutional waste generating sites. Its purpose is to monitor outgoing wastes for detectable levels of medium and high energy gamma and x-ray radiation.

1.2 Description

The system is modular in its construction and consists of two remote Radiation Detector assemblies with individual sodium iodide [NaI(TI)] scintillators and PMTs in lead-shielded, weatherproof housings and a System Control Unit.

The Radiation Detector assemblies are installed at a location convenient for monitoring packaged wastes. The System Control Unit (Figure 1) is housed in a table-top cabinet for installation in any convenient indoor location. These modules are interconnected by means of coaxial cables which are supplied with the Radiation Detector assemblies.

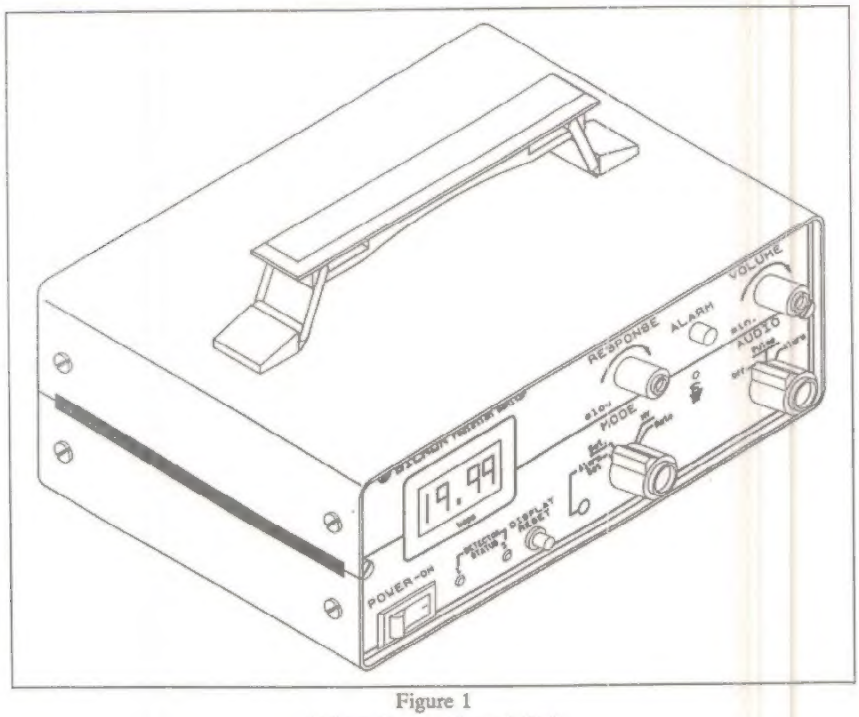

Figure 1
LFM-2 System Control Unit

1.0 Introduction (cont'd)

1.3 Specifications

Detector Complement:
Two two-inch diameter NaI(Tl) scintillation detectors, each contained in a lead-shielded, weatherproof PVC housing.

Radiation Detected:
Medium and high-energy Gamma and X-rays.

Sensitivity:
Will detect 75 μCuries of ^{137}Cs at ten feet from a detector and 10 μCuries of ^{137}Cs at 3 feet 8 inches from a detector in a normal background of ten μRem per hour.

Range:
0-200,000 cpm (counts per minute) in two linear ranges. Factory set for 20,000 cpm full scale.

Accuracy:
Within 5% of reading above 20% of full scale.

HV:
Adjustable up to 1600 VDC. Supplies HV to the Radiation Detector assemblies.

Remote Detector Connectors:
Two MHV.

Response Time - Signal:
Continuously adjustable from 2 to 20 seconds.

Response Time - LCD display:
Less than one second in Alarm Set, Battery check, and HV modes, and six seconds in Rate mode.

Power Requirements:
105-125 VAC, 50-60 Hz.

Battery:
Rechargeable gelled cell which provides 12 hours (minimum) of backup operation between charges.

Recharge:
Regulated; 16 hours when batteries have reached 10.0 VDC on the LCD display. Charging is automatic whenever unit is connected to an AC line.

Battery Dependence:
Less than 10% change in reading from fully charged to 10.0 VDC.

LCD Display: 3 1/2 digit display (1999) with 1.8 cm (0.7 in.) high digits.

Detector Status:
Two green LED's are illuminated whenever detector activity is sensed; one LED is assigned to each detector. An LED turns off if the corresponding detector does not produce any activity for a 15-second period (non-latching).

Shock:
100G per lightweight machine of MIL-STD 202C, method 202B.

Vibration:
5G in each of three mutually orthogonal axes at one or more frequencies from 10-33 Hz.

Controls:
Response control, Volume control, four-position Mode Switch, three-position Audio Switch, display Reset Switch, Power ON/OFF Switch, Ratemeter Sensitivity Switch (internally mounted).

1.0 Introduction (cont'd)
1.3 Specifications (cont'd)

Audio:
Switch selectable to provide an audible "click" for each detector pulse and an audible alarm above the alarm set point, an audible alarm only, or disable audio output.

Audio Volume:
Adjustable when "AUDIO" Switch is in the "Pulse" position. Disabled (full volume) whenever an alarm condition occurs, or when "AUDIO" Switch is in the "Alarm" position.

Alarm:
Audible, non-latching rate alarm with front panel adjustment from 10% to 130% of full scale with readout on the LCD display. Red LED alarm indicator on front panel.

Display Reset:
Pushbutton switch which quickly zeros the LCD display in the "Rate" mode.

Recorder Output:
Rear panel BNC connector provides 100 mV signal for a full scale (20 kcpm or 200 kcpm) LCD display reading. The output will drive 100 kohm loads.

Temperature:
System Control Unit: operational from -20° to +50°C (+4°F to +122°F).
Detectors: operational from -35°C to +50°C (-31°F to +122°F).

Size:
25.4 cm wide x 12.2 cm high x 19.8 cm deep (10.0 in. x 4.8 in. x 7.8 in.) including case top handle, excluding all detectors and cables.

Weight:
2.5 kg (5.5 pounds) excluding all detectors and cables.

Construction:
All-aluminum case with textured polyurethane paint finish and silk-screened nomenclature.

Power Cord Connector:
3-wire type with 1/4 amp fuse. UL approved.

2.0 Operating Instructions

2.1 General

The operation of the BICRON LFM-2 Radiation Monitor is straightforward and requires only a minimum of operator attention. It is important, however, that the system be operated according to these instructions for it to be effective in screening for radiation.

The status of the system is indicated by green and red lights on the panel, by a digital display, and by an audible alarm signal (Figure 2). Green lights indicate that the Radiation Detector assemblies are connected and operational. Red indicates an alarm condition.

There is a series of knobs and switches on the front panel. Most of these are used only when setting up the unit for the first time and when performing routine tests. Only the red "DISPLAY RESET" Button is necessary under normal conditions. Section 3.0 Controls and Adjustments describes the function of each of the controls on the system.

2.2 Monitoring

After the initial set-up, the system should function without needing operator attention, except as outlined below.

To make best use of the system, it is important to understand three basic facts:

1. The system constantly monitors radiation, whether waste packages are moving, stopped between the detectors, or not present at all.

2. The detectors are directional - they are designed to monitor the space between them, but not beside or behind them. The region that is monitored is similar to the area that would be lighted if the detectors were spotlights with broad beams.

3. The system responds quickly to high radiation fields, but requires more time to detect low levels.

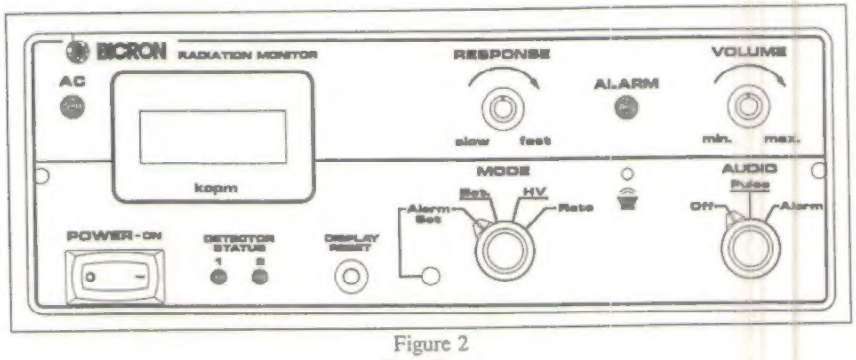

Figure 2
Front Panel

2.0 Operating Instructions (cont'd)
2.2 Monitoring (cont'd)

For these reasons, *it is important that the workers move the packages slowly into the monitoring position and stop with the center of the package between the detectors. After 15 seconds the worker should move the package slowly away.* In this way, the system can scan the entire package, from front to rear, not just the center portion.

The slower the packages are moved, the better the scan will be. More time looking at each region of the package will improve the detection probability.

It is normal for an occasional false alarm to occur due to the random variations in background radiation. This may happen more frequently when it is raining. The operator should simply reset the alarm and the system should return to normal.

2.2.1 Precautions

There are some precautions to follow to prevent inaccurate readings:

1. Instruct the workers to move packages slowly into position and slowly away, as explained above.

2. Under certain unusual conditions, the system may alarm when a package is some distance away from the detectors, but not while it is between the detectors. This may cause some confusion if there is more than one package in the area. Be sure to survey all these packages individually to determine the cause of the alarm.

2.2.2 Normal Conditions

Under normal conditions, when there is no radiation detected above the alarm set point, the green lights will stay on, and there will be no audible alarm and no red light. You may, however, notice slight changes in the readings on the LCD display due to fluctuations in background radiation.

2.2.3 Alarm Conditions

If the system has detected radiation above the alarm limits, the "ALARM" light and sounder come on. The alarm will usually occur while the package is between the detectors. It also may occur while the package is moving into or out of position.

While procedures may vary, we recommend that you take the following steps when an alarm occurs:

1. First, move the package through the detectors at least two more times. If the system alarms again, the alarm is probably caused by radiation in the package.

NOTE: Please observe the precautions in Section 2.2.1 Precautions.

2. Using a survey meter which is calibrated in mR/h (a unit of radiation exposure rate), survey the package to determine the extent of the radiation hazard which may be present.

3. Disposition of packages containing radioactive materials, as well as guidelines for what is considered "too high" depend upon local, state and federal regulations. Follow the procedures established at your institution.

2.0 Operating Instructions (cont'd)

2.3 Visual Check

Make it a point to look at the Control Unit every now and then. Make sure that the two green "DETECTOR STATUS" lights for Detector #1 and Detector #2 are lit, and that the digital display is registering a "background" reading within the range that you would expect.

Make sure that no one has changed the settings of any of the controls. Remember that all of the control knobs on the front panel will usually be turned fully clockwise, unless otherwise noted.

Look at the rear panel of the instrument to be sure that cable #1 is connected to input #1 and cable #2 is connected to input #2 (Figure 3). If someone has moved the system, these might have been improperly re-connected.

2.4 Source Check

Test the system on a regular basis (daily or weekly) using a small radioactive source.

1. Turn the "MODE" Switch to the "Alarm Set" position. Make sure that the alarm set point has not changed from the value that was established during the set-up procedure. Turn the "MODE" Switch back to the "Rate" position.

2. Obtain a Coleman or equivalent brand of lantern mantel. There may be one or more mantels in the package (typically three). Do not open the plastic envelope. Place it in a small food storage bag.

   Note: Most lantern mantels contain trace amounts of thorium which emits small amounts of radiation, some mantels have no thorium.

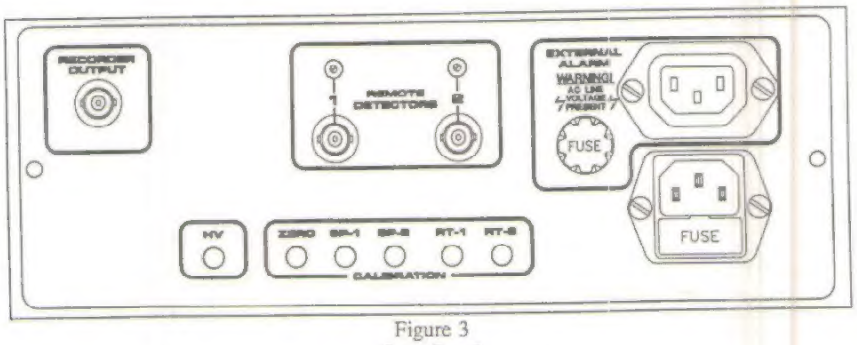

Figure 3
Rear Panel

2.0 Operating Instructions (cont'd)
2.4 Source Check (cont'd)

3. Tape the food storage bag on the front surface of Radiation Detector #1, so that the lantern mantle is in the center of the circular face of the detector. The system should alarm.

NOTE: Do not reset the system by pressing the red "ALARM" Button on the front panel. If the sound is too annoying, temporarily turn the "AUDIO" Switch to "Off".

4. Wait 30 seconds or more, then record the reading.

5. Remove the lantern mantle from Detector #1 and place it in a similar position on Detector #2. Repeat steps 3 and 4 above for Detector #2.

6. Compare these readings with previous records. Any significant deviation in readings over a period of time may indicate a detector problem.

   NOTE: Be sure the AUDIO switch is turned to ALARM after you are done with this test.

7. Store the food storage bag containing the lantern mantel in a safe place so that it may be reused on every test. If you must purchase new lantern mantels, be aware that you may get different readings.

3.0 Controls and Adjustments

3.1 Introduction

While there may seem to be a lot of controls on the front panel, each serves a purpose and it is important to understand what each one does.

NOTE: All of the controls which have external knobs on them should normally be turned fully clockwise. (See descriptions below). This does NOT include screwdriver adjustments.

3.2 Description of Controls

3.2.1 Mode Switch

This switch is the heart of the instrument's controls (Figure 4). It has four functions.

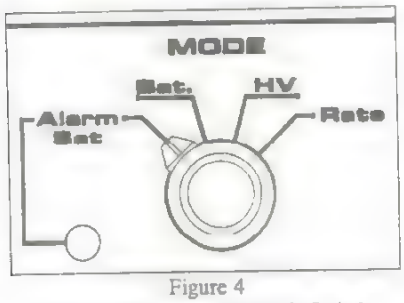

Figure 4
"MODE" (Ratemeter Control) Switch

Alarm Set

In this position, the LCD display shows the level at which the alarm will be activated when the "MODE" Switch is in the "Rate" position. This level is user-adjustable from 1% to 130% of full scale via the Alarm Set Potentiometer found immediately below the words "Alarm Set". A small, flat-blade screwdriver is required for the adjustment.

Bat.

This function displays the condition of the internal batteries. The reading on the LCD display should be greater than 10.0 VDC.

If the unit is not connected to AC power and the LCD display reading is at or below 10.0 VDC, the instrument should be connected to AC power to prevent deep battery discharge.

If AC power is present, the fuse is good, and the LCD display reading is at or below 10.0 VDC, have the unit serviced by qualified personnel.

If the batteries appear unable to retain a charge, they may require replacement. Refer to section 5.2.2 Battery Replacement for instructions.

NOTE: Always check the condition of the batteries prior to using the instrument, even if the unit is connected to the AC line. Do not use the instrument if the LCD display indicates a battery voltage less than 10.0 VDC.

HV

In this position, the LCD display shows the high voltage setting for the detectors. The display should indicate the value which is recorded on the Certificate of Calibration, plus or minus 10 volts. For example, if the value on the certificate is 1150V, then 1140 to 1160V is acceptable.

NOTE: Always check the high voltage prior to using the instrument. Detector damage and/or erroneous readings may result from improper high voltage settings.

3.0 Controls and Adjustments (cont'd)
3.2 Description of Controls (cont'd)
3.2.1 Mode Switch (cont'd)

Rate

In this position, the count rate, in thousands of counts per minute (kcpm), is displayed on the LCD display. Two full scale sensitivities are available: 20 kcpm (20.00 on the LCD display) or 200 kcpm (200.0 kcpm on the LCD display). The standard factory setting is for 20 kcpm.

"Rate" is the normal setting of the "MODE" Switch.

To change the full scale sensitivity, proceed as follows:

1. Disconnect the AC power cord from the AC line.

2. Remove the top cover from the instrument by removing the four pan head screws that hold it in place.

3. Inside the unit there is a long circuit board connected directly to the front panel. Directly behind the red "ALARM" LED is a two position slide switch. To set the full scale sensitivity for 20 kcpm, slide the switch to the right.

   The circuit board to the right of the switch is marked "20K". To set the full scale sensitivity for 200 kcpm, slide the switch to the left. The circuit board to the left of the switch is marked "200K".

4. Replace the cover when finished.

3.2.2 Audio Switch

The audio switch (Figure 5) controls the functions of the internally mounted speaker. It has three settings.

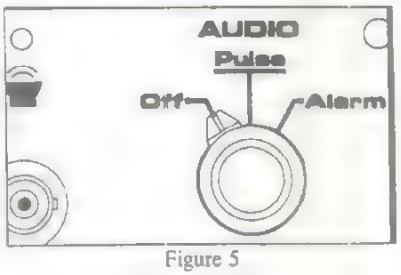

Figure 5
"AUDIO" Switch

Off

The speaker is disabled.

Pulse

The speaker provides an audible "click" for each detector event. Whenever the Alarm Set Level is exceeded in the "Rate" Mode, the clicking is replaced with a loud tone to indicate the alarm condition.

Alarm

The "Alarm" Position is similar to the "Pulse" Position, except that the audible clicking is disabled. "Alarm" is the normal setting of the "AUDIO" Switch.

3.2.3 Volume Control

This control enables you to adjust the loudness of the audible "clicking" when the "AUDIO" Switch is in the "Pulse" Position. Clockwise rotation increases audio volume.

The "VOLUME" Control has no effect on the audio speaker when an alarm condition occurs. The speaker provides a full volume, continuous tone in both the "Pulse" and "Alarm" positions. However, to make it easy to remember how the front panel controls should be set, we recommend that all of them be set to their fully clockwise positions normally. Thus, fully clockwise is the normal setting of the "VOLUME" Control.

3.0 Controls and Adjustments (cont'd)
3.2 Description of Controls (cont'd)

3.2.4 Response Control

This control provides a continuously adjustable response time to incoming signals from the external detectors connected to the unit. Response time is defined as the time it takes the display to go from 0 to 90% of a final reading. Full counterclockwise rotation of the control knob provides a 20 second response time. Full clockwise rotation provides two seconds.

The "RESPONSE" control is active only when the "MODE" Switch is in the "Rate" position. The "RESPONSE" control is inactive when the "MODE" Switch is in the "Alarm Set", "Bat.", and "HV" positions.

This control can be thought of as a "smoothing" or "filtering" of occasional statistical fluctuations that normally occur with radiation detection. The more "filtering" that you provide, the "smoother" the average detected count rate will be. However, the price paid for this "filtering" is that it makes the unit more sluggish to any changes that the external detectors see, including valid increases in the radiation detected. By connecting a strip chart recorder to the recorder output connector on the rear panel, you can visually observe the effect of the "RESPONSE" control on the unit's response to radiation detection. Refer to Section 3.2.10 Recorder Output.

Experience has shown that in most cases it is best to set this control for maximum response speed. Thus, "fast" is the normal setting of the "RESPONSE" Control.

3.2.5 Display Reset

This pushbutton switch provides rapid LCD display zeroing. It is typically used whenever a "RESPONSE" control adjustment is made in the "Rate" mode. This switch also functions as an Alarm Reset pushbutton.

To reset the LCD display to zero, press the "DISPLAY RESET" Switch. The LCD display has a six second update time when the "MODE" Switch is in the "Rate" position, so it may take up to six seconds for the LCD display to zero.

When this switch is depressed with the "MODE" Switch is in the "Alarm Set", "Bat.", or "HV" modes, the LCD display will reset to a value near zero, and then quickly return to the value that was observed prior to depressing the switch.

3.2.6 Alarm Light

This visual indicator lights whenever the alarm set point is exceeded in the "Rate" Mode.

As a test, the "ALARM" light turns on whenever the "MODE" Switch is in the "Alarm Set", "Bat.", or "HV" positions. This serves as a reminder to keep the "MODE" Switch in the "Rate" Position.

3.2.7 Remote Detector Connectors

The remote detector connectors are MHV-type connectors located on the rear panel of the instrument (Figure 3). They are to be used with the two remote Radiation Detector Assemblies and coaxial cables that were provided with the unit. Note that the two MHV connectors, the remote Radiation Detector assemblies, and the two coax cables are marked "1" and "2"

Caution: Always switch the power OFF before removing or connecting a detector to the instrument.

NOTE: Match cable number 1 with detector number 1 on the remote detector input number 1. Match cable number 2 with detector number 2 on remote detector input number 2. The instrument will not function properly if these items are mismatched.

3.0 Controls and Adjustments (cont'd)
3.2 Description of Controls (cont'd)

3.2.8 Detector Status Lights

These two green lights, located on the instrument front panel, monitor the activity of the two external Radiation Detector Assemblies connected to the unit.

Each light is assigned to a detector and its corresponding counting electronics. As long as the detector is operating properly (that is, the instrument receives a valid, usable signal from the detector), and the counting electronics associated with that detector are working, the green light will remain lit.

If the instrument does not receive a signal from an external detector for more than 15 seconds, or its associated counting electronics do not produce pulses reflecting this detector activity for more than 15 seconds, then the corresponding detector status light will turn off, indicating a possible detector or counting electronics failure. If this occurs, refer the unit to qualified personnel for servicing.

3.2.9 Power Switch

This switch, located on the front panel, turns the unit on and off. Push the rocker switch to the right to turn the unit on

3.2.10 Recorder Output

This output is located on the rear panel of the instrument. It provides an analog output that tracks the LCD display on the front panel. The connector is a BNC type.

The output voltage of the recorder output is factory set for 100 mV for a full scale (20.0 or 200.0 kcpm) LCD reading. The output will drive 100 kohm loads.

4.0 Installation Instructions

4.1 Introduction

The Bicron LFM-2 is a modular system consisting of a System Control Unit, two remote Radiation Detector assemblies, and interconnecting cables.

NOTE: The Detector Assemblies are designed to withstand the normal outdoor environment once they are installed. Use extreme caution, however, when handling them during the installation process. In particular, do not drop the Detector Assemblies, and do not bend or twist the cables excessively.

These instructions, together with the accompanying drawings, provide a recommended procedure that you should follow in installing the system.

4.2 System Control Unit

This unit, shown in Dwg. No. SK050191, is to be installed in an indoor area. A location must be chosen which is near to the Radiation Detector Assemblies because the maximum cable length is 100 feet.

4.2.1 Mounting

The Control Unit is designed to be set on a table top or shelf. The unit measures 25.4 cm wide x 13.7 cm high x 19.3 cm deep (10.0 in. x 5.4 in. x 7.8 in.).

4.2.2 Positioning

Typically, the control unit should be placed where the front-panel display and controls will be accessible. Choose an area where the controls will not be inadvertently changed, and where papers, coffee cups, etc. will not be placed on top of the unit.

Allow a space of approximately 6 inches behind the unit for access to cable connections.

4.2.3 Wiring

The Control Unit requires 105 to 125 Volt, 60 Hz AC power at a maximum of 50 watts. The system will withstand normal line fluctuations, so an ordinary AC outlet will usually suffice. Under unusual conditions, a dedicated line or power line filter may be necessary.

All cable connections are made to the rear of the Control Unit. Cable runs are described in Section 4.4 Cable Runs.

4.0 Installation Instructions (cont'd)

4.3 Remote Radiation Detector Assemblies

Two Radiation Detector assemblies are provided. See Dwg. No. 9700129. They are to be installed so that waste packages can be moved between them.

4.3.1 Mounting

The detectors should be rigidly mounted on customer-supplied hardware. See Dwg. No. B9700146 for a recommended installation.

4.3.2 Positioning

The detectors are directional -- they are designed to measure radiation most effectively through the flat surface opposite the cable entrance point.

When standing between the detector assemblies, the flat end surface should be facing toward you, and the cables should be facing away from you.

The detectors should be at the mid-point of the waste package. The closer the detectors are to the package sides, the greater the system's sensitivity.

4.4 Cable Runs

Two types of cables are included with the system, a power cable and interconnecting cables.

4.4.1 Power Cable for the Control Unit

This is a standard 3-conductor power supply cord with a grounding plug (NEMA 5-15P) for connection to the 115 volt AC power line.

Plug the power cord securely into the receptacle on the rear of the Control Unit. After the installation is complete, plug the cord into the 115 volt AC power outlet.

4.4.2 Interconnecting Cable

The Detector Assemblies are fitted with coaxial cables through waterproof strain-relief connectors. On the other end of each cable is an MHV connector (a bayonet-style metal connector that mates with the receptacle on the rear of the Control Unit).

NOTE: Do not splice or cut the cable and do not substitute another type of cable.

BICRON ◆ NE recommends that these interconnecting cable runs be enclosed in weatherproof, metal conduit except inside the checking building.

Ground the metal conduit. This will minimize electrical interference which might otherwise cause false alarms.

Avoid any situation where the cables will be subject to wear, abrasion, or other physical abuse. The system will NOT function reliably unless the cable runs are adequately shielded and protected.

4.0 Installation Instructions (cont'd)

4.5 Initial Setup

1. Be sure that the system has been installed properly according to the instructions in Sections 4.1 through 4.4 and that you understand the operation of the controls as explained in Section 3.0 Controls and Adjustments.

2. Turn the instrument on. Be sure that the controls are all set in their normal positions as explained in Section 3.0 Controls and Adjustments. Usually it is best to turn all controls that have external knobs to their fully clockwise positions.

3. Observe the readings on the digital display. You will notice that a number will appear for about six seconds, then a new number will appear. Every few minutes, write down some of these numbers, and continue this process for 1 or 2 hours.

   These are called "background" readings. They are a measure of the normal radiation levels which always exist.

   There should be no packages between the detectors when you are recording these readings. Wait at least 15 seconds after removing a package before recording a background reading.

   If you have an outdoor installation, you may notice that the background readings increase when it is raining.

4. Compute the average of these readings.

5. Calculate the alarm set point according to the following table:

Background KCPM	Alarm Set Point
2.00	3.47
2.20	3.74
2.40	4.00
2.60	4.28
2.80	4.54
3.00	4.80
3.20	5.06

6. Turn the "MODE" switch to the "Alarm Set" Position. With a small screwdriver, set the alarm level to the value obtained from the chart. If the background is between values listed in the table, choose an alarm set point which is between the listed values also.

   Example: If the average background reading you observed was 2.50 kcpm (which is halfway between the listed values of 2.40 and 2.60), set the alarm level to 4.14. kcpm, which is halfway between 4.00 and 4.28.

   This setting may take a little patience. It does not have to be exact, but should be within plus or minus 0.02 or 0.03 kcpm.

7. Leave the system turned on and observe how it operates over the next day or so.

   If no alarms are sounded when there are no packages between the detectors, then the setup is satisfactory. Record the alarm set point for future reference.

   If false alarms are frequent, then increase the alarm set point in increments of 0.10 kcpm until the false

4.0 Installation Instructions (cont'd)
4.5 Initial Setup (cont'd)

alarm problem disappears. The alarm set point should NOT be set at a level which is more than two times the background level. Record the alarm set point for future reference.

NOTE: It is best to set the alarm level to the lowest value which does not produce annoying "nuisance" alarms. If you set the level too high, you will make the system less sensitive, and it will not meet published specifications.

8. Perform the source check outlined in Section 2.4 Source Check and record the readings obtained for future reference. The readings obtained include the background, so if background changes, expect the source check to vary accordingly.

NOTE: If either of the readings is near 1999 (or 19.99 or 199.9, depending on the range) on the digital display, remove and discard one of the lantern mantles from the plastic bag and try again. Then seal the bag. Use this same bag containing these same lantern mantles as the check source for all future tests.

5.0 Maintenance
5.1 Fuse Replacement

To check or replace a fuse, remove the power cord from the AC cord receptacle. Gently pry out the fuse holder with a small, flat-blade screwdriver by rocking the screwdriver back and forth along the bottom edge of the holder.

The holder can accommodate up to 2 fuses; one is a spare. The rear fuse is the active fuse, the front is a spare. The fuse holder snaps into place by pressing it back into the power cord receptacle.

The replacement fuse is BUSS GMA-1/4 or equivalent.

CAUTION: Do not substitute other types of fuses, as this may affect safety and performance. If the fuse blows frequently, have the system serviced.

5.2 Battery Maintenance
5.2.1 Recharging

The internal 6 VDC gelled-cell batteries are automatically recharged whenever the unit is connected to the AC line. The charger is both voltage and current regulated. Charging occurs regardless of the state of the power switch (on or off).

If the unit is connected to the AC power line and the power fails, the batteries automatically take over as the power source for the instrument without interruption (provided that the batteries have sufficient charge). Fully charged batteries can provide greater than 12 hours of continuous service.

With power off, fully discharged batteries require approximately 16 hours to become fully charged. With the power on, the recharge time is somewhat longer.

Longest battery life will be obtained if the unit is kept plugged into the AC outlet whenever it is being used.

5.0 Maintenance (cont'd)
5.2 Battery Maintenance (cont'd)

5.2.2 Replacement

Gelled-cell batteries can provide 2 to 4 years service under normal use. A battery which fails to hold sufficient charge should be replaced. It is best to replace both batteries at once since the life expectancy of each is about the same.

Battery replacement is simple; proceed as follows:

1. Turn the power switch OFF. Disconnect the AC power cord from the AC line.

2. Remove the top cover by removing the four pan head screws that hold it in place.

3. Disconnect the red and black wires from the battery terminals.

4. Loosen the battery retaining clip from the case bottom with a nut driver. Remove and replace the batteries with two 6 VDC, 1 A-h gelled cell batteries (Bicron Part No. 9750005).

5. Connect the red wire from the circuit board to the "+" terminal of one of the batteries.

   Connect the wire from the main circuit board to the"-" terminal of the other battery.

   Take the small wire (usually yellow) that formerly connected the two old batteries two each other and use it to connect the two new batteries to each other by attaching it to the two unused terminals on the two new batteries.

6. Be sure to tighten the battery retainer clip before replacing the case top.

5.3 Calibration

The instrument is calibrated electronically using a variable frequency pulse generator and specific radiation sources. The calibration pots are located on the rear panel of the instrument.

When the instrument has been calibrated, a Certificate of Calibration is completed, which then becomes part of this manual.

A detailed calibration procedure is a part of the QC Acceptance Procedure (Part No. 1100930) found in Appendix A. Recalibration is required after servicing and at the regular intervals which may be specified by appropriate regulatory agencies, but no less than once per year.

Calibration should be performed by BICRON ◆ NE at its factory or by a qualified service organization.

Appendix A

BICRON QC Acceptance Procedure for Model LFM-2 Radiation Monitor (Part Number 1100930) follows this page.

HARSHAW TLD BICRON
NE-TECHNOLOGY

BICRON • NE
6801 Cochran Road
Solon, Ohio 44139
Telephone: (216) 248-7400
(800) 472-5656
Telefax: (216) 349-6581

Model LFM-2
Radioactive Material Detection System

Quality Control Acceptance Procedure

Publication No. 1100-0-Q-0996-001

* * * Release Date * * *

September 13, 1996

Part No. 1100930
Rev. A

This procedure is carried out at the BICRON ♦ NE factory prior to shipment of the system. Note that it requires the use of a considerable amount of test equipment, as well as specific radioactive sources.

CAUTION: This procedure should be performed only by qualified personnel since AC line voltage is present inside the unit, and because it requires the proper handling of radioactive materials.

1.0 Visual Inspection

Remove the top cover of the instrument. Perform a visual inspection of the finished product. See Figure 1 for the location of all components not located on the rear panel.

2.0 Fuse Installation

Remove the fuse holder from the rear panel. Install a Buss GMA 1/4 amp (or equivalent) fuse in the rear fuse compartment and replace the holder.

3.0 Power Supply Tests

Disconnect the red wire from the "+" terminal of the 6 VDC battery to which it is connected. Turn the Power Switch on the front panel to "Off". Inspect all AC power wiring between the rear panel and the main PC board. Inspect the 110/220 jumper

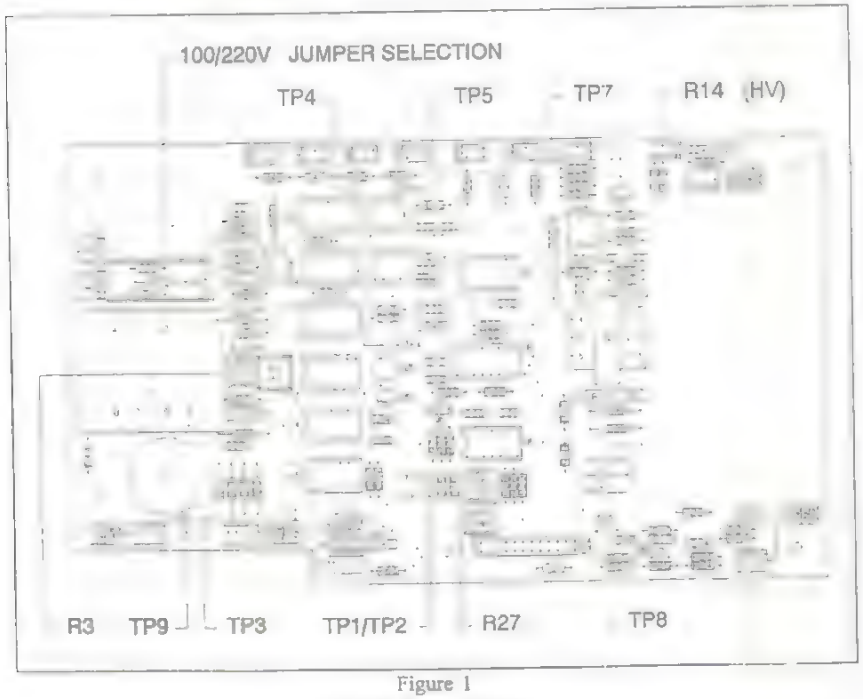

Figure 1
Main Circuit Board

3.0 Power Supply Tests (cont'd)

selection on the main board (two jumpers, as marked, for 110 VAC operation; one jumper, as marked, for 220 VAC operation). Connect the unit to AC power via the power cord connector on the rear panel. Perform the following tests and calibrations on the power supply:

1. Observe the AC power indicator on the left side of the front panel; it should be illuminated. Unplug the power cord from the AC power and wait ten seconds. The AC power indicator should turn off. Reconnect the AC power cord.

2. Connect a voltmeter between the disconnected red wire and ground (TP9). Turn the Power Switch on. Adjust R3 (5 kohm +14 VDC adjustment potentiometer) until the voltmeter reads 14.0 ± 0.1 VDC. Disconnect the voltmeter when finished.

3. Turn the Power Switch off. Connect a fused ammeter between the disconnected red wire and the battery terminal which contains a black wire from the main PC board. Turn the Power Switch on. You should see a reading of 110 ± 25 mADC. Disconnect the ammeter when finished.

4. Leave the Power Switch on. Connect a voltmeter between the +7 VDC power supply (TP5) and ground (TP9). The voltage should be 7.5 ± 0.5 VDC.

5. Leave the Power Switch on. Connect a voltmeter between the -7 VDC power supply (TP7) and ground (TP9). The voltage should read -6.7 ± 0.5 VDC.

6. Turn the Power Switch off. The +7 and -7 VDC supplies should discharge to near 0 VDC. Connect the voltmeter again between the + 14 VDC supply (between the red battery wire and ground). The reading should be approximately 0.2 - 0.6 VDC higher than the value noted in Step 3. This is normal and is due to the batteries having been removed from the circuit. The purpose of this test is to observe that the +14 VDC is present regardless of the state of the power switch.

7. Disconnect all test equipment from the power supplies. Reconnect the red wire to the "+" battery terminal from which it was removed.

8. Turn the Power Switch on. Observe that power is reaching the switch board by rotating the Mode Switch and noting meter/LED activity. Leave the ratemeter switch in one of the positions that keeps the alarm LED on.

   Leave the Power Switch on. Remove and reconnect the AC power cord from the unit a few times. After doing this, keep the AC power cord disconnected. The alarm LED should remain on. This test is to see that the batteries automatically take over whenever the AC power is removed from the unit.

Note: If the batteries are discharged, this test may fail. Recharge the batteries overnight by connecting the unit to AC power, and then repeat the test.

4.0 Ratemeter Tests

If the batteries have a sufficient charge, leave the AC power cord disconnected. Perform the following tests on the ratemeter section of the instrument:

1. Leave the Power Switch on. Connect a voltmeter between pin 5 of U13 (on the switch board) and ground. The reading should be -7.5 VDC ± 0.5 VDC.

2. Connect a voltmeter between pin 36 of U12 and ground. Adjust R92 (1 Volt Reference) until you see a reading of 1.000 ± 0.01 VDC.

3. Connect a voltmeter between pin 6 of U17 and ground. Adjust R53 (Zero) until you see a reading of 0.5 ± 0.2 mVDC.

4. Turn the "MODE" Switch to the "HV" Position. Connect a voltmeter with an input impedance greater than or equal to 1000 megohms to either of the rear panel MHV Connectors (Remote Detector 1 or 2). Adjust R14 (HV) until the voltmeter reads 1000 ± 3 VDC.

5. Adjust R55 (SP-2) until the LCD display reads 1000 ± 20 VDC. To test linearity, change the high voltage to 500 VDC using R14 (HV). The LCD display should read 500 ± 10 VDC. Adjust the high voltage to 1500 VDC using R14 (HV). The LCD display should read 1500 ± 30 VDC. Disconnect the voltmeter when finished.

6 Turn the "MODE" Switch to the "Bat." Position. Connect a voltmeter between the red wire on the "+" battery terminal and ground. The reading on the display and the reading on the voltmeter should be within 10% of each other.

7. Connect a voltmeter across pins 7 (+) and 6 (-) of U14. Adjust R106 (Remote Detector #1 Threshold) until the voltmeter reads 100 ± 10mVDC.

8. Connect a voltmeter across pins 5 (+) and 4 (-) of U 14. Adjust R110 (Remote Detector #2 Threshold) until the voltmeter reads 100 ± 10mVDC.

9. Turn the "MODE" Switch to the "Rate" position. Adjust R27 (Threshold) fully clockwise to disable.

10. Connect a variable frequency pulse generator that is capable of withstanding high voltage at its output to either of the rear panel "REMOTE DETECTORS" Connectors. If the pulse generator is not designed to accept high voltage at its output, turn the high voltage off by turning R14 (HV) fully counter-clockwise. Allow several minutes for the high voltage to discharge before connecting the pulse generator.

11. Leave the "MODE" Switch in the "Rate" position. Adjust the "RESPONSE" Control for "Fast" response. Turn the "AUDIO" Switch to the "Alarm" Position. Adjust the "Alarm Set" Potentiometer to its midpoint (12 o'clock position). Slide SW5 (Rate Selection Switch) to the "20K" position.

12. Slowly increase the frequency of the pulse generator until the speaker indicates an alarm condition. Carefully note the EXACT LCD reading at which the alarm condition occurs. Turn the "MODE" Switch to the "Alarm Set" position. Adjust R65 (SP-1) until the LCD display reading is the same as the one noted above.

4.0 Ratemeter Tests (cont'd)

13. To test linearity, adjust the "Alarm Set" Potentiometer until the LCD display reads 15.00 kcpm. Turn the "MODE" Switch to the RATE position. Slowly increase the frequency of the pulse generator until an alarm condition occurs. It should be 15.00 ± 1.5 kcpm. Turn the "MODE" Switch to the "Alarm Set" position. Adjust the "Alarm Set" Potentiometer until the LCD display reads 3.60 kcpm. Turn the "MODE" Switch to the "Rate" position. Turn the pulse generator off, and press the "DISPLAY RESET" Switch. Pressing this switch should reset the LCD display. Release the "RESET" Switch. Turn the pulse generator back on. Slowly increase the frequency of the pulse generator until an alarm condition occurs. It should be 3.6 ± 0.4 kcpm.

14. Slide SW5 (Rate Selection Switch) to the "200K" position. Repeat Step 13 for alarm set points of 150.0 kcpm and 36.0 kcpm. For 150.0 kcpm, the reading should be 150.0 ± 15.0 kcpm, and for 36.0 kcpm, the reading should be 36.0 ± 3.6 kcpm. Leave the pulse generator connected when you finish this step.

5.0 Ratemeter Count Rate Calibration

Perform the following ratemeter count rate calibration:

1. Leave the Power Switch ON. Leave the "MODE" Switch in the "Rate" Position. Leave the "RESPONSE" Control set for "Fast" response. Slide SW5 (Rate Selection Switch) to the "20K" position.

2. Adjust the pulse generator for a frequency of 250 Hz. Adjust R50 (RT-2) until the LCD display reads 15.00 kcpm.

3. Adjust the pulse generator for a frequency of 60.0 Hz. The reading should be 3.60 kcpm.

4. Slide SW5 (Rate Selection Switch) to the "200K" position. Adjust the pulse generator for a frequency of 2500 Hz. Adjust R52 (RT-1) until the LCD display reads 150.0 kcpm.

5. Adjust the pulse generator for a frequency of 600 Hz. The reading should be 36.0 kcpm.

6. Use Table 1 when calibrating the count rate section of the instrument.

7. Record all count rates on a Certificate of Calibration.

8. Leave the pulse generator connected when the calibration is completed.

Range (kcpm)	Pulse Generator Output (Hz)	Simulated kcpm	Acceptable LCD Reading (kcpm)
200 (75%)	2500	150.0	135.0 - 165.0
200 (25%)	600	36.0	32.4 - 39.6
20 (75%)	250	15.00	13.50 - 16.50
20 (25%)	60	3.60	3.24 - 3.96

Table 1 - Count Rate Calibration Table

6.0 Ratemeter Adjustments

Continue testing the ratemeter section of the circuit, as follows:

1. Leave the "MODE" Switch in the "Rate" Position. Leave the "RESPONSE" Control set for "Fast" response. Slide SW5 (Rate Selection Switch) to the "20K" position. Adjust the pulse generator for a reading on the LCD display of 19.80 kcpm. Turn off the pulse generator. The LCD display should read 2.00 kcpm in 2 seconds or less.

NOTE: The LCD display itself has a response time of 6-8 seconds, so this test is only a quick check of the fast response. Refer to the note after step 2 for an alternate method.

Adjust the "RESPONSE" Control for "Slow" response. Press the "DISPLAY RESET" Switch. Turn the pulse generator on. The LCD display should read 18.00 kcpm in 20 to 25 seconds.

2. Slide SW5 (Rate Selection Switch) to the "200K" position. Repeat Step 1 using an LCD display reading of 198.0 kcpm.

Note that the LCD has an update period of approximately 6-8 seconds itself. The tests in Step 1 and the first paragraph of this step are a quick check of the "RESPONSE" Control.

A more accurate test is to connect a voltmeter from pin 6 of U17 to ground. The voltage measured when the LCD display reads 19.8 kcpm (or 198.0 kcpm) becomes the reference voltage. When you turn off the pulse generator, the time it takes the voltage to go from its reference value to 10% of its reference value is defined as the response time. Likewise, when you turn the pulse generator back on, if you start at 0 VDC on the voltmeter, the response time is defined as the time it takes to go from 0 to 90% of the reference voltage.

Leave the pulse generator connected when this test is completed.

3. Leave the "MODE" Switch in the "Rate" Position. Leave SW5 (Rate Selection Switch) in the "200K" position. Adjust the "RESPONSE" Control for "Fast" response. Adjust the "Alarm Set" Potentiometer to its midpoint (12 o'clock position). Turn the "AUDIO" Switch to the "Pulse" Position. Set the frequency of the pulse generator so that the alarm set point is not exceeded. An audible clicking (one click for each generated pulse) should be heard. Increase the frequency of the pulse generator until the alarm set point is exceeded. The alarm should enable, and the "ALARM" LED should illuminate.

4. Decrease the frequency of the pulse generator until the count rate is below the alarm set point. You should hear the audible clicking again. Test the "VOLUME" Control for proper operation. Leave the "VOLUME" control in the "Min." Position. Increase the frequency of the pulse generator until the alarm set point is exceeded. The alarm should enable at full volume, independent of the setting of the "VOLUME" Control.

5. Repeat Steps 3 and 4 with SW5 (Rate Selection Switch) set to the "20K" position.

6.0 Ratemeter Adjustments (cont'd)

6. Repeat Steps 3 and 4 with the "ALARM" Switch in the "Alarm" Position and SW5 (Rate Selection Switch) set to the "200K" position. When the pulse generator frequency is below the alarm set point, the sounder should be silent. When the pulse generator frequency is above the alarm set point, the alarm should enable at full volume, independent of the setting of the "VOLUME" Control.

7 Repeat Step 5 with SW5 (Rate Selection Switch) set to the "20K" position.

Leave SW5 (Rate Selection Switch) in the "20K" position. Turn the "AUDIO" Switch to the "Pulse" Position. Turn the "MODE" Switch to the "HV" position. The "ALARM" LED should illuminate (as a test of the LED), and the sounder should be silent. Repeat this test for "MODE" Switch settings in the "Bat." and "Alarm Set" positions.

Repeat Step 8 with SW5 (Rate Selection Switch) set to the "200K" position.

10 Connect the pulse generator to the rear panel "REMOTE DETECTOR" number 1 MHV connector. Turn the pulse generator on (frequency is unimportant). "DETECTOR STATUS" LED number 1 should illuminate. Turn off the pulse generator. "DETECTOR STATUS" LED number 1 should turn off after 15-20 seconds.

11. Repeat Step 10 with the pulse generator connected to the rear panel "REMOTE DETECTOR" No. 2 MHV connector. Check the "DETECTOR STATUS" LED No. 2 for proper operation.

12. Leave the pulse generator connected. Connect a voltmeter across the rear panel "RECORDER OUTPUT" BNC Connector. Turn the "MODE" Switch to the "Rate" position. Adjust the frequency of the pulse generator until you see an LCD display reading of either 10.00 kcpm or 100.0 kcpm (depending on the setting of SW5, the Rate Selection Switch setting). Adjust R30 (Recorder) until the voltmeter reads 50 mVDC. To test linearity, adjust the frequency of the pulse generator until the LCD display reads 16.00 kcpm (or 160.0 kcpm). The voltmeter should read 80 mVDC. Adjust the frequency of the pulse generator until the LCD display reads 4.00 kcpm (or 40.0 kcpm). The voltmeter should read 20 mVDC.

7.0 Discriminator and HV Adjustment

Note: This Discriminator and HV Adjustment procedure should be followed whenever a Remote Detector is replaced, or a change is made in a cable length or type.

1. Disconnect all test equipment.

2. Obtain the following check source (or its equivalent): a 1 microcurie Iodine-129 source (BICRON #100). This source emits photons primarily in the 30-35 keV region.

3 Connect the EXACT cables and detectors that will be used by the customer.

4 Obtain a BICRON Labtech™ Scaler/ Ratemeter Analyzer. Set the threshold to 50 mV and the window to 100 mV. Set the Analyzer to the Channel 1 Position.

5 Connect the detector with the lower gain to the Labtech. This is usually the Detector with the longer cable.

6 Using the HV Control on the Labtech, center the 30-35 KeV I-129 peak in the window. Record the HV reading on the Certificate of Calibration.

7 Connect the Detector with the higher gain to the Labtech. This is usually the Detector with the shorter cable.

8. Using the threshold control (not the HV) on the Labtech, center the 30-35 keV I-129 peak in the window. Record the threshold reading on the Certificate of Calibration

9. Adjust the rear panel HV control on the LFM-2 to the value obtained in Step 6.

10. Connect a millivoltmeter to the discriminator test points for channel 1. (See Section 4.0 Ratemeter Tests Step 7.) Set the discriminator to the value obtained for channel 1. Record this value on the Certificate of Calibration.

11. Connect a millivoltmeter to the discriminator test points for channel 2. (See Section 4.0 Ratementer Tests Step 8.) Set the discriminator to the value obtained in Step 10.

12. Turn the "MODE" Switch to "Alarm Set". Set the "Alarm Set" control based on the following formula:

$$\sqrt{\frac{avg\ Bkg.}{30}} \times 180 + avg.\ Bkg = Alarm\ Setting$$

Avg. Bkg. is the average of 12 background readings with both detectors connected.

8.0 Final Checkout

1. Reassemble the instrument case.

2 Complete, date, and sign the Certificate of Calibration.

BKG ALARM (PER 12)

2040
2733
3490
4143
4800
5444
6078
6705
7324

Appendix B

The following BICRON Spare Parts List identifies all the major subassemblies in this model. Each of these components may be ordered from BICRON. If you desire more detailed information about the components of these assemblies, contract the BICRON Electronic Products Technical Service Department.

Part No.	Quan.	Description
1086010	1	Main PCB Assembly
1086020	1	Front Panel PCB Assembly
1086030	1	Rear Panel PCB Assembly
1086140	1	Front Panel Subassembly
1086050	1	Rear Panel Final Assembly
9750005	1	Battery, 6 volt, 1 amp-hour
9760001	1	Fuse, 1/4 Amp
9801024	1	Cable Assembly, 10-pin
1100900	1	User's Manual

Appendix C

The following BICRON ♦ NE Drawings follow this page:

9700129	Detector Assembly
9700146	Recommended Installation
9700329	Main PCB Assembly Part Location Drawing
9700330	Front Panel PCB Assembly Part Location Drawing
9700331	Rear Panel PCB Assembly Part Location Drawing
1086920	Schematic Circuit diagram (sheets 1 and 2)

labtech™

Specifications

DETECTOR: Choice of GM and scintillation detectors

HIGH VOLTAGE: Electronically stabilized, adjustable to > 1600 V (typically 2000V) via a turns counting dial, with readout on the meter

CONNECTOR (detector): MHV

INPUT SENSITIVITY: Adjustable from 0.1 to 1V via a turns counting dial

WARMUP TIME: None

POWER REQUIREMENTS: AC, 110V/60 Hz or 220V/50 Hz, switch selectable

BATTERY: Rechargeable gelled cell which provides 8 hrs of operation

RECHARGE: Automatic when unit is connected to line power; unit may be either on or off

AUDIO: Switch-selectable to provide an audible 'click' for each detector pulse, or an audible alarm

ALARM: Audible, non-latching rate alarm with front panel adjustment from 30% to 130% of full scale and readout on the meter.

AUDIO CONTROL: Three position rotary switch

TEMPERATURE: Operational from -20° to +50°C

HUMIDITY: < 5% change in reading from 10-95% RH

SIZE: 12.5"L x 7.5"D x 5.5"H including feet and folded handle (31.8 x 19.1 x 14.0 cm)

WEIGHT: 7.5 lbs. (3.4kg)

SCALER SECTION

OPERATING MODES: Switch-selectable as follows:
Manual - continuous counting
Preset Time - 0.1 to 999.9 min. in 0.1 min. increments, stored in memory
Preset Count - 100 to 999,000 counts in 100 count increments, stored in memory
Test - Exclusive self-test of scaler operation

RANGE: 0-9,999,999 counts; 0-99,999.99 minutes

TIMER: Crystal controlled time base with an accuracy of 0.05% or better, AC or battery power

DISPLAYS: Seven decade LED; indicator lamps for 'elapsed', 'preset', 'minutes' and 'counts'

CONTROLS: Four position rotary switch; push buttons for count, hold, reset and set

RATEMETER SECTION

RANGE: 0-1,000,000 CPM in four linear ranges

ACCURACY: Within 10% of reading between 20% and 100% of full scale on any range

RESPONSE TIME: Switch-selectable, optimized for each range, 0-90% of final reading as follows:

Range	Time	
	Fast	Slow
X1	12 sec	20 sec
X10	1 sec	8 sec
X100	<1 sec.	2 sec
X1000	<1 sec	1 sec

METER: Ruggedized, recessed, high-torque 1 mA meter with 3.35 inch (8.51 cm) scale marked 0-1000 counts per minute and 0-2.0 kilovolts, with 'bat ok' band

RECORDER OUTPUT: 1 volt full scale into 1 megohm load

CONTROLS: Seven position rotary switch; rotary fast/slow response switch

SINGLE CHANNEL ANALYZER

MODES: Selected by front-panel control as follows:
Channel 1: Accepts signals within the analyzer window only
Channel 2: Accepts signals above the analyzer window only
Out: Accepts all signals above the lower-level discriminator

LOWER-LEVEL DISCRIMINATOR: Adjustable from < 0.1 to 1 V via a turns counting dial

WINDOW: Adjustable from 0 to 1 V above the lower-level discriminator setting via a turns counting dial

PULSE-PAIR RESOLUTION: Typically 10 μs or less

Manufacturer reserves right to alter specifications

BICRON

Bicron Corporation
12345 Kinsman Road
Newbury, Ohio 44065
Telephone (216) 564-2251
Telex 980474

Bicron Corporation
European Office P.O. Box 271
2410 AG Bodegraven The Netherlands
Telephone 017 26/14243
Telex 39772

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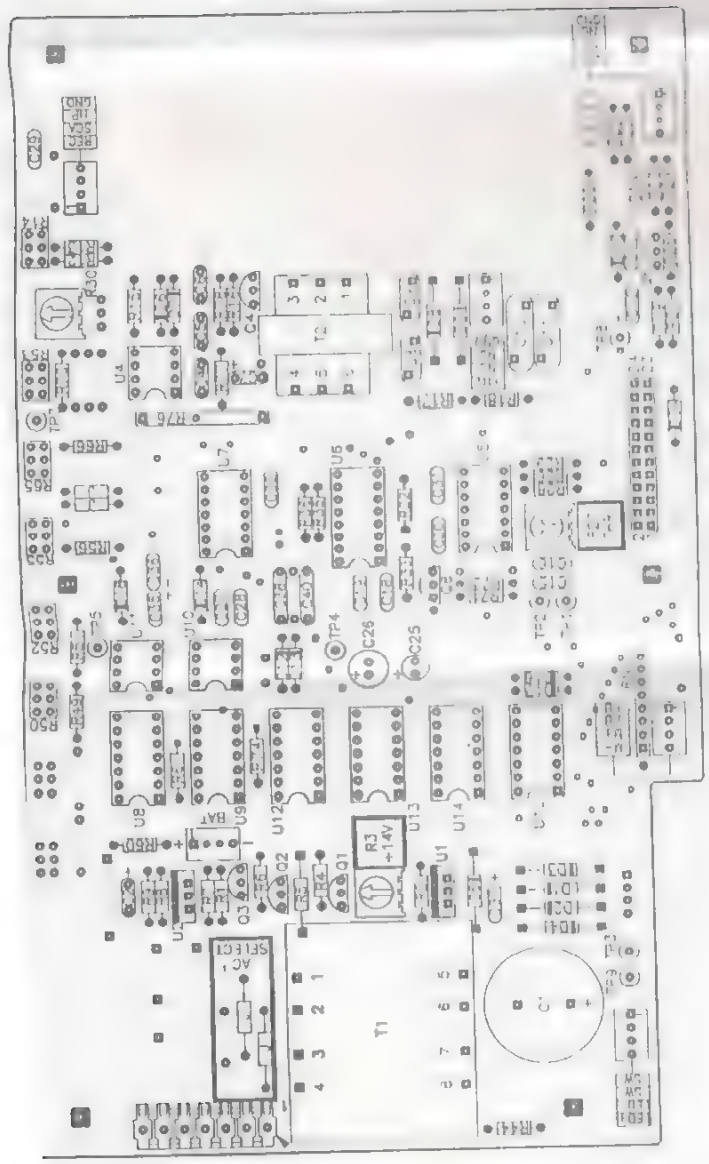
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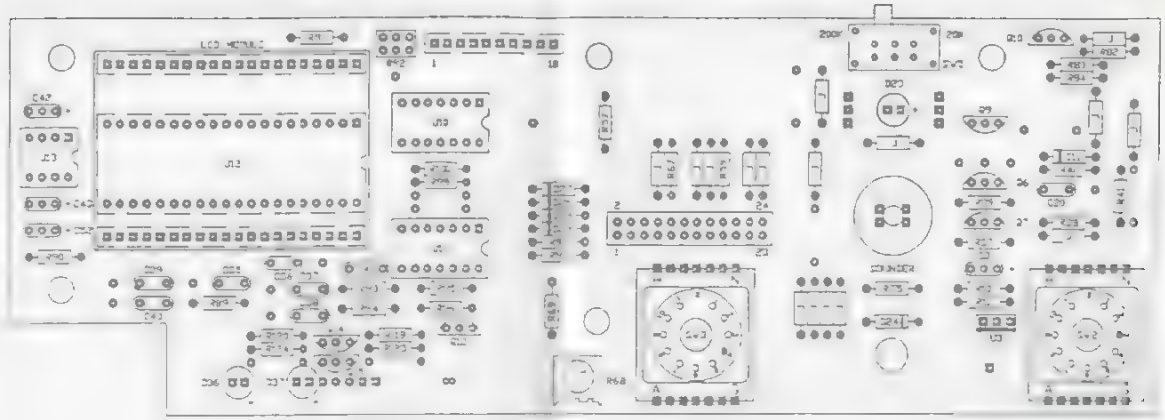
U14
Q1
Q2
Q3



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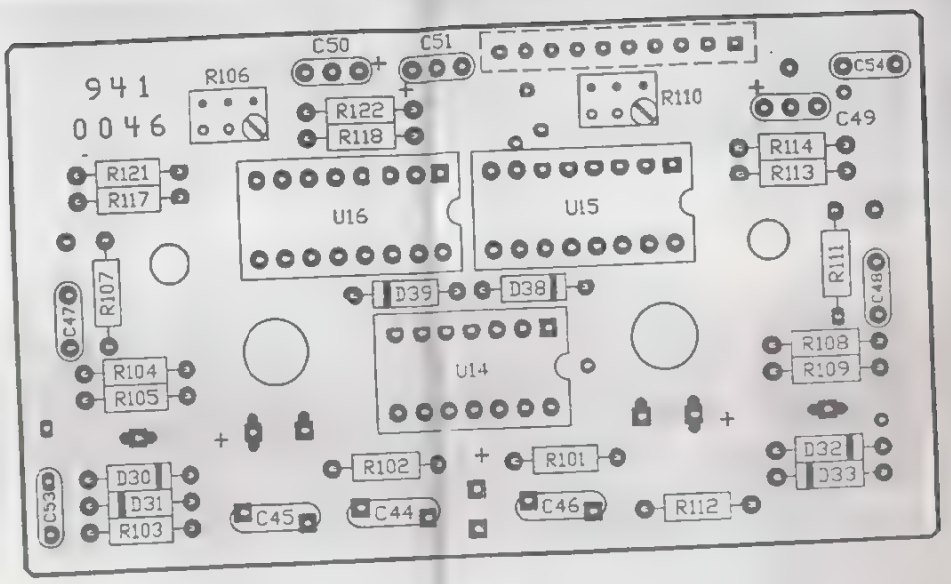
941
0046
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C51
R122
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R114
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R107
C47
D39
D38
R111
C48
U14
R108
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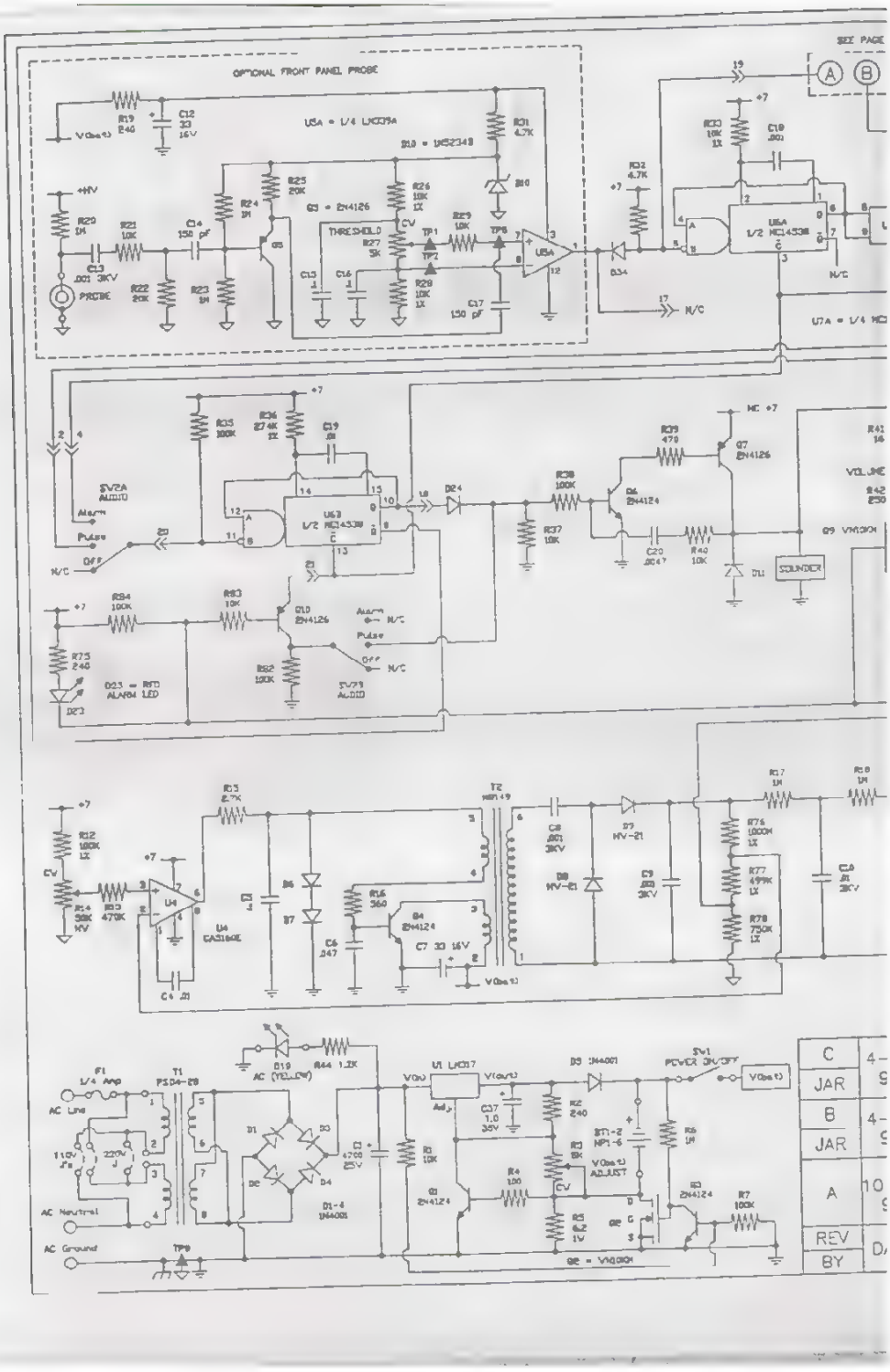
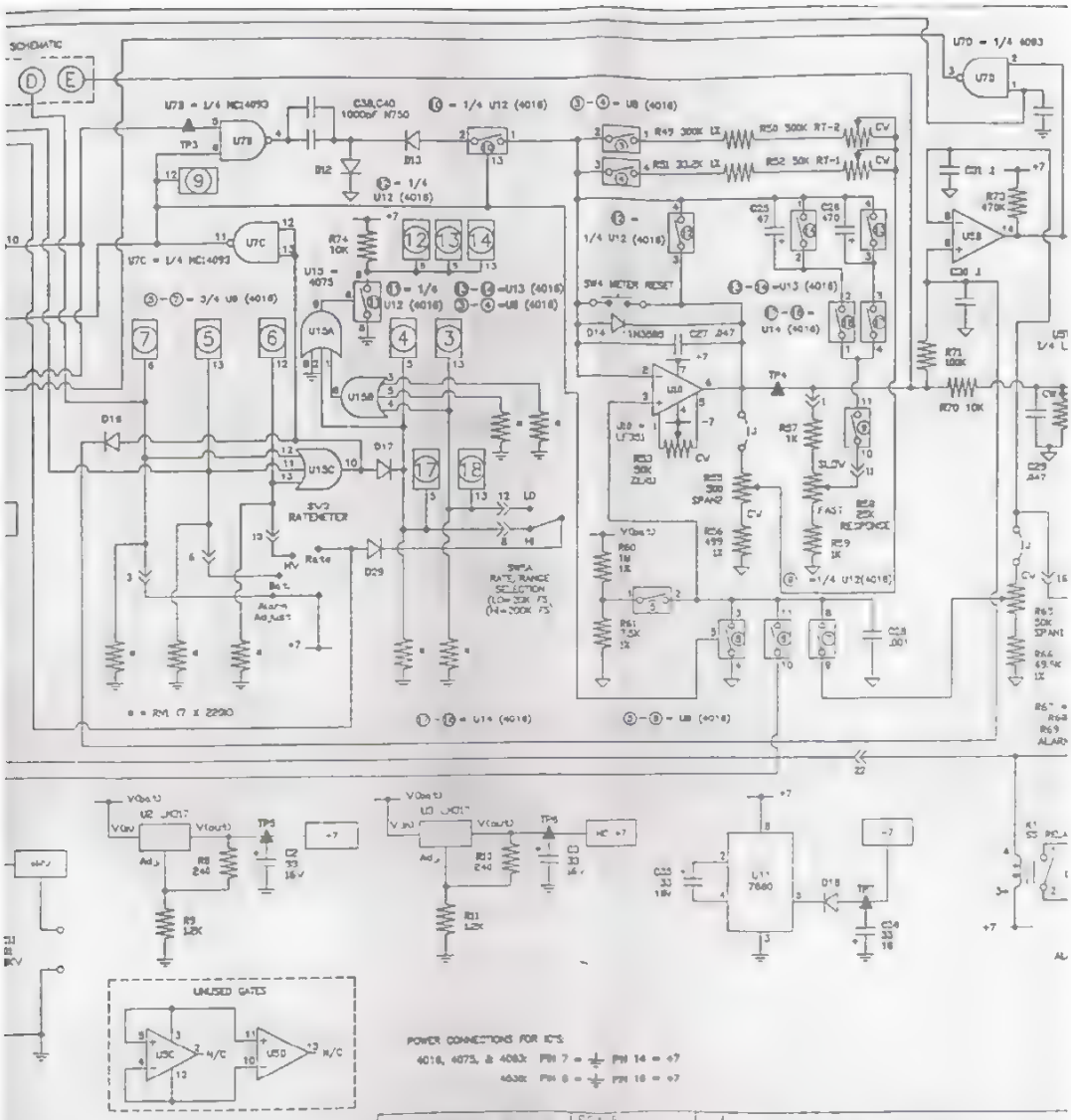
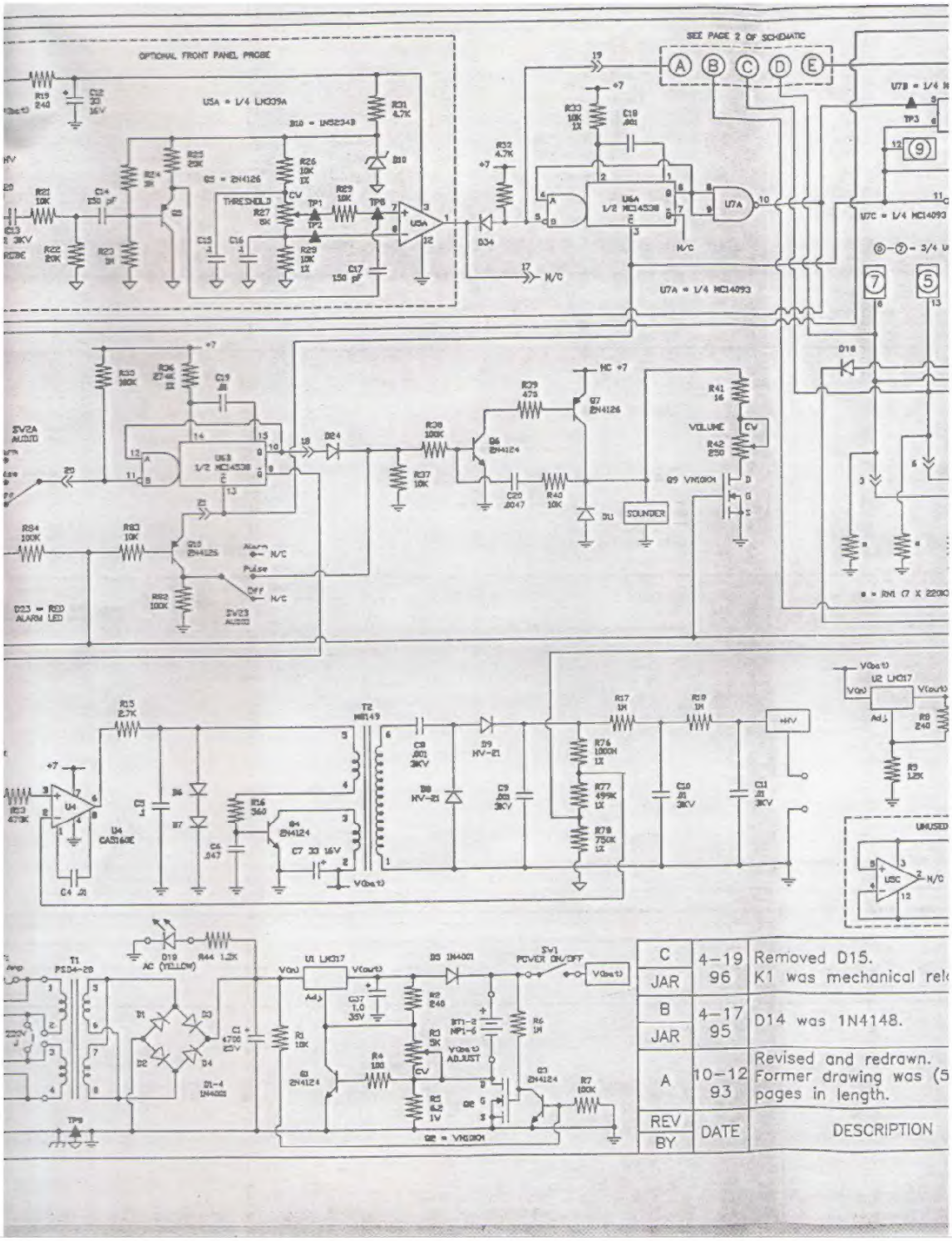
R101
C46
R112
D32
D33

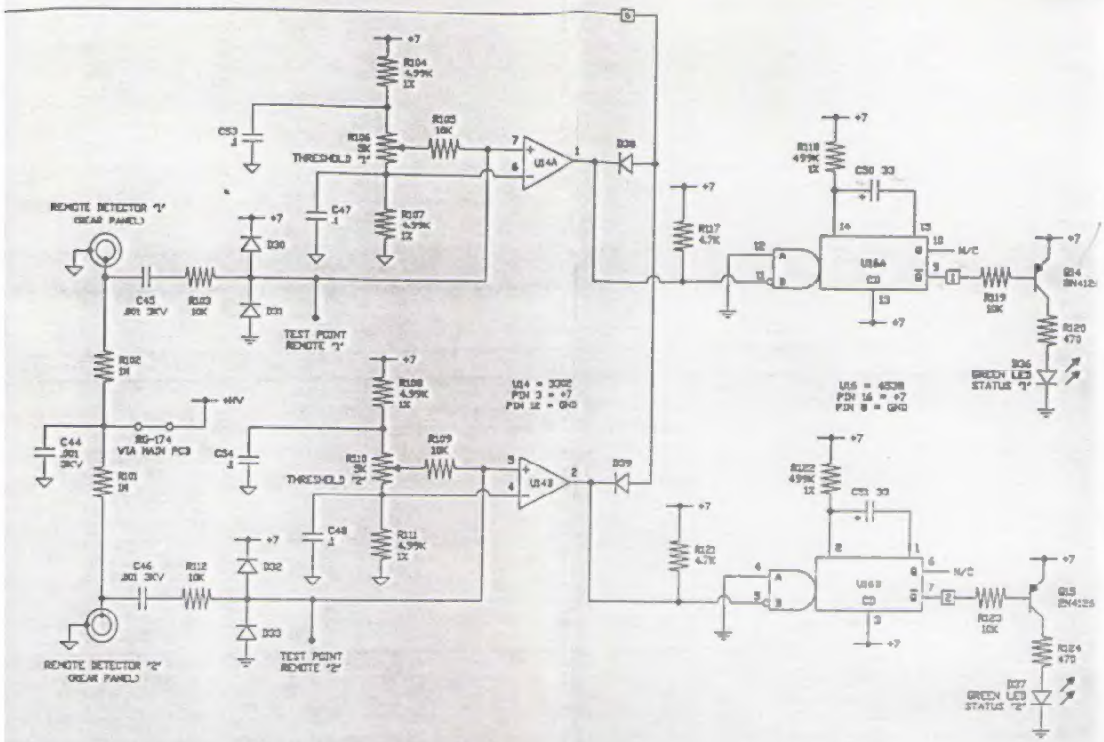

OPTIONAL FRONT PANEL PROBE
SEE PAGE
U5A = 1/4 LM339A
D10 = LM5234B
Q3 = 2N4126
THRESHOLD
PROBE
U5A 1/2 MC14538
U7A = 1/4 MC
SV2A AUDIO
Alarm
Pulse
Off
U6B 1/2 MC14538
Q7 2N4126
Q9 VN1206
SOUNDER
Q10 2N4126
SV2B AUDIO
D23 = RED ALARM LED
T2 MBP149
U4 CA3140E
D7 HV-21
D8 HV-21
Q4 2N4124
F1 1/4 Amp
T1 PS04-28
AC Line
AC Neutral
AC Ground
110V
220V
D1-4 1N4001
U1 LM317
Adj
D19 (YELLOW)
D9 1N4001
SV1 POWER ON/OFF
VOUT ADJUST
Q1 2N4124
Q2 2N4124
Q2 = VN1206
C
JAR
B
JAR
A
REV
BY

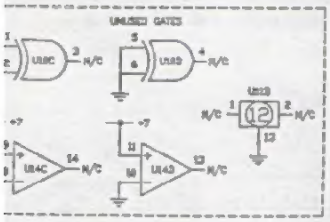


Removed D15. K1 was mechanical relay.	N1142 JR	TOLERANCES UNLESS OTHERWISE SPECIFIED	SCALE NONE	HARSHAW BICRON RADIATION MEASUREMENT PRODUCTS
D14 was 1N4148.	N1065	FRAC. X .XX. .XXX. NONE ANGLES MICRO FIN: √	DRAWN 2-17-90 JAR	NEWBURY, OHIO U.S.A.
Revised and redrawn. Former drawing was (5) pages in length.	JAR	DE-BURR AND BREAK ALL EDGES	CHECKED JR DATE 4/27/90	Schematic Circuit Diagr Radiation Monitor Pg 1
DESCRIPTION	ECN BY	DO NOT SCALE PRINT	CAGE CODE B	BASIC PART NUMBER 1086920

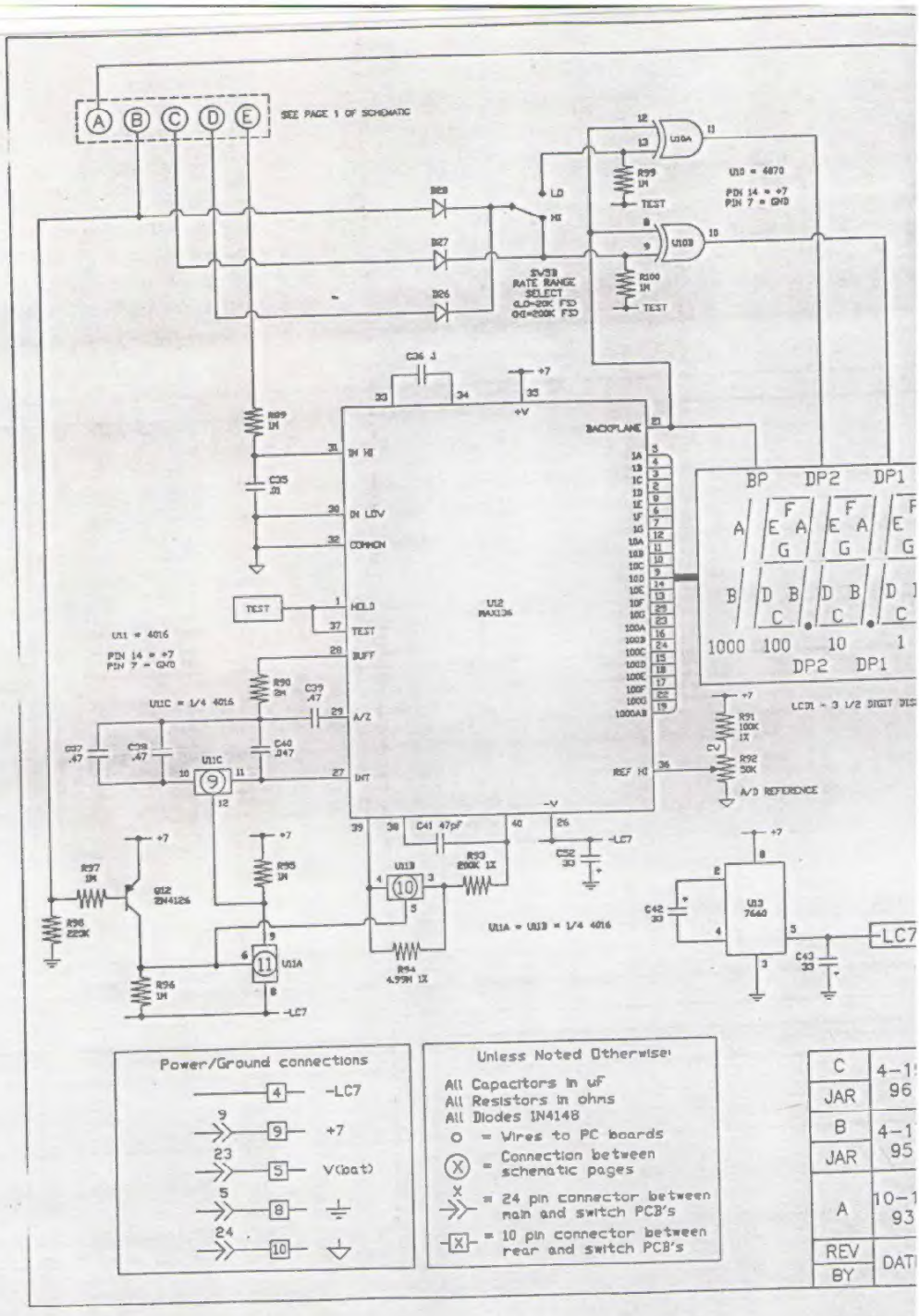


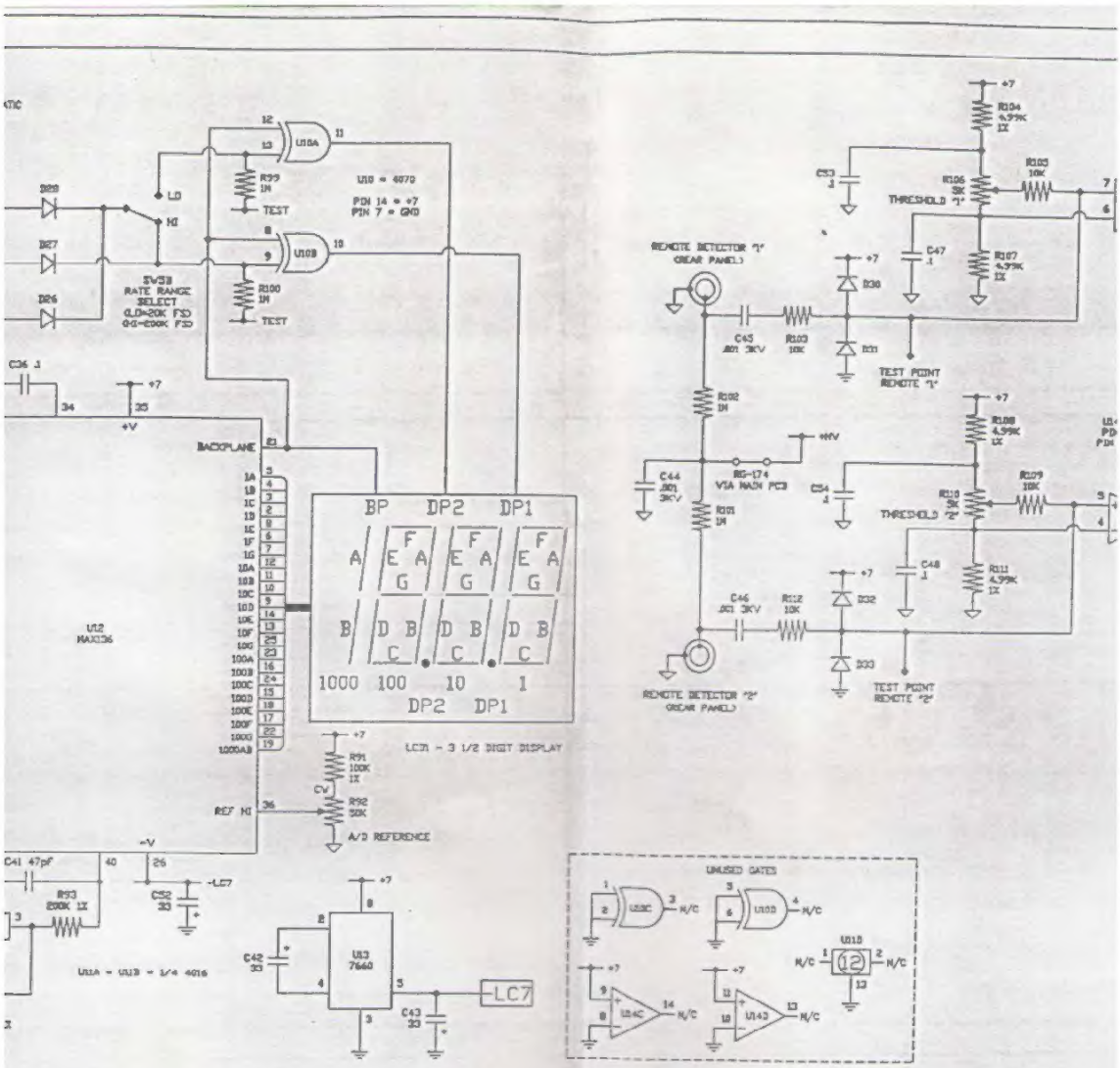
REV	DATE	DESCRIPTION
C JAR	4-19 96	Removed D15. K1 was mechanical rel
B JAR	4-17 95	D14 was 1N4148.
A	10-12 93	Revised and redrawn. Former drawing was (5 pages in length.





ved D15.	N1142	TOLERANCES UNLESS OTHERWISE SPECIFIED	SCALE: NONE	HARSHAW BICRON RADIATION MEASUREMENT PRODUCTS	
is mechanical relay.	JR	FRAC.:	DRAWN: 2-17-90	SOLON, OHIO U.S.A.	
was 1N4148.	N1065	.X:	DATE: JAR	Schematic Circuit Diagram	
d and redrawn. r drawing was (5) in length.	JAR	.XX: NONE .XXX: ANGLES: MICRO FIN.: √	CHECKED: JR	Radiation Monitor Pg 2 of 2	
DESCRIPTION	ECN / BY	DE-BURR AND BREAK ALL EDGES	DATE: 4/22/96 DO NOT SCALE PRINT	DWG. SIZE: B	BASIC PART NUMBER: 1086920 REV.: C


A B C D E
SEE PAGE 1 OF SCHEMATIC
U10A
U10B
U10 = 4070
PIN 14 = +7
PIN 7 = GND
R99 1M
R100 1M
TEST
LO
HI
D29
D27
D26
SW3B
RATE RANGE SELECT
LO=20K FSD
HI=200K FSD
C36 .1
+7
+V
-V
BACKPLANE
R89 1M
IN HI
C35 .01
IN LOV
COMMON
TEST
HOLD
TEST
BUFF
A/Z
INT
U12
MAX136
REF HI
U11 = 4016
PIN 14 = +7
PIN 7 = GND
U11C = 1/4 4016
R90 2M
C39 .47
C37 .47
C38 .47
C40 .047
U11C
U11A = U11B = 1/4 4016
R97 1M
R95 1M
R96 220K
R96 1M
Q12 2N4126
U11A
U11B
R93 200K 1%
R94 4.99M 1%
C41 47pF
C52 33
-LC7
U13 7660
C42 33
C43 33
LC7
R91 100K 1%
R92 50K
A/D REFERENCE
LCD1 = 3 1/2 DIGIT DISP
BP DP2 DP1
1000 100 10 1
DP2 DP1
Power/Ground connections
4 -LC7
9 9 +7
23 5 V(bat)
5 8
24 10
Unless Noted Otherwise:
All Capacitors in uF
All Resistors in ohms
All Diodes IN4148
O = Wires to PC boards
(X) = Connection between schematic pages
X = 24 pin connector between main and switch PCB's
X = 10 pin connector between rear and switch PCB's
C 4-1
JAR 96
B 4-1
JAR 95
A 10-1
93
REV
BY
DAT



Unless Noted Otherwise:

All Capacitors in uF
All Resistors in ohms
All Diodes 1N4148

O = Wires to PC boards

(X) = Connection between schematic pages

= 24 pin connector between main and switch PCB's

= 10 pin connector between rear and switch PCB's

REV	DATE	DESCRIPTION	ECN	BY
C	4-19-96	Removed D15. K1 was mechanical relay.	N1142	JAR
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A	10-12-93	Revised and redrawn. Former drawing was (5) pages in length.		JAR

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.:
.X:
.XX:
.XXX: NONE
ANGLES:
MICRO FIN.: √

DE-BURR AND BREAK ALL EDGES